Towards Hard Real–Time Erlang

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HRT systems: what since now?

- Hard Real–Time (HRT) constraints are common in many application fields, such as:
  - Control systems (locomotion, security,...)
  - Manufacturing
  - Signal processing
  - Telecom

- HRT applications are often been developed using C, C++, Ada on top of RT operating systems

- Other “main–stream” languages, such as Java, approached the problem of RT only recently

- Nowadays, RT systems are quickly moving towards embedded architectures and solutions
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Functional programming paradigm can help a lot in modeling, defining, developing, testing and maintaining RT systems.

In particular, Erlang/OTP has been successfully used for massively concurrent soft real-time systems.

Erlang/OTP gives some basic functionalities that are really useful in developing RT systems:
- A huge and complete standard library
- OTP, which gives a lot of power and flexibility to manage large systems with a lot of cooperating processes even in distributed environments
- The possibility of building and deploy embedded Erlang applications in an easy and reliable way

We think that Erlang has much to say even in the field of HRT systems, but it lacks native HRT support!
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2. Scheduling in Erlang
3. HARTE: A proposal for RT Erlang
4. Tests
5. Open Issues
The Actual Emulator Scheduler.....

- The Erlang scheduler does not have support for HRT tasks.
- It is a Multi–Queue Round–Robin scheduler.
- There are basically three documented levels of priority for processes: *low*, *normal* and *high*. A fourth priority level (*max*) is undocumented and reserved for a couple of system processes.
- All user Erlang processes usually run with *normal* priority, and usage of different priority levels (especially of *high*) is highly discouraged.
- So the Erlang native scheduler cannot guarantee HRT:
  - No deadline specification for processes
  - No guarantees that a process would finally be scheduled (starvation problems arise using *high* and *normal* prio with strange spawning patterns.....)
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</tr>
<tr>
<td>HIGH</td>
<td></td>
</tr>
<tr>
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<td></td>
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Towards RT Erlang processes

In order to have HRT capabilities in Erlang, three different approaches are possible:

- Writing from scratch a new scheduler for the emulator
  Unfeasible: the scheduler is really entangled with much of the system Existing Erlang code should continue to work anyway

- Modifying the existing MQRR scheduler to support realtime
  Hard: a lot of C code to guarantee HRT

- Adding HRT as a service, which is an erlang application which provides HRT capabilities. This is what this paper is all about :-)

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5. Open Issues
Motivations

Scheduling in Erlang

HARTE: A proposal for RT Erlang

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ERLANG EMULATOR

PROC_1

PROC_2

PROC_3

PROC_n

OS SCHEDULER
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ERLANG EMULATOR

rt_task
rt_task
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HARTE

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HARTE: an overview

- HARTE is basically an application (a peculiar one), which is in charge of scheduling RT task
- In order to guarantee RT scheduling of task, HARTE itself runs with MAX priority (*)
- All HARTE tasks (i.e. HRT tasks the user would run), are created as low priority tasks and put in a scheduling queue using a Deadline Monotonic (DM) scheduling algorithm
- Then the scheduler is started and it schedules tasks one by one, modifying the priority of the task to be run to HIGH (*)
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- START_LINK
- INITIALIZE
  - add_task
  - run
- MISSION
  - schedule
- TERMINATE
  - stop
Details: init
Initialisation

- A new behaviour called `rt_fsm` has been defined. It is basically a `gen_fsm` with some additional code for RT management.
- Each HRT task is represented by an `rt_fsm`.
- In the initialisation phase, all RT tasks are defined and added to the scheduler.
- To add a task to the scheduler, the `init` function of `rt_fsm` calls `rt_scheduler:add_task()`,
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HARTE scheduler is started by calling `rt_scheduler:run()`.

From there on task to be run are picked up from the queue and scheduled.

To schedule a task, we modify its priority from low to high.

In order to do that, the BIF `process_flag/3`, in order to let a process change the priority of another process to a level not higher than his own priority level.

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- We tested it with a couple of heavy CPU–bound benchmark, running both HARTE tasks and normal erlang processes at the same time.
- The scheduler overhead, in different configurations, is reported in table:

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Test 1: four HRT tasks
Test 2: RT tasks and 50 normal erlang processes
Test 3: HRT tasks with different periods
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- Support for real–time message passing has to be introduced (a preliminary solution exists!)
- An EDF scheduling policy should be adopted and becomes compulsory when you have RT message passing.
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